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ABSTRACT

In any democratic system, the schooling of technology is ultimately a matter of negotiation at a variety of levels, even when, as currently in England and Wales, the central government seeks to define a statutory technology curriculum. This paper presents findings of a study that examined the technology education provided in three high schools in northern England. Specifically, the study sought to describe the curricular, pedagogical, institutional, and other dimensions of school technology education in the three schools and to examine the ways in which they attempted to develop and assess students' "technological capability." The study was conducted during 1990-92, after the passage of the 1988 Education Act but before the relevant parts of the statutory order defining the technology curriculum came into effect. Data were derived through observation, document analysis, and interviews with relevant teaching staff and some students in year 10. Findings indicate that the schooling of technological activity is shaped by two processes--curricularization and intellectualization. The schools reflected what might be called "design" and "application" approaches to the construction of a school-technology curriculum. However, whatever approach is used, it is susceptible to the movement toward intellectual codification and away from the practical. The programs lacked a balance between the quality of and pride in technological artifacts themselves and a recognition of the cognitive dimension of technical practice. (LMI)

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Knowledge in action ? An ethnographic study of high school design and technology

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Introduction

The form, content and pedagogy of a new component, such as technology, within a school curriculum, is the outcome of complex, contingent and interacting factors. Many of these factors are social and personal. Some stem from institutional constraints and practices. Others derive from personal conviction and preferences about, for example, how students learn or should be taught, or about the nature and purpose of technology as an educational activity. These convictions and preferences will be different not only among teachers but among all those concerned to promote technology within school curricula , e.g. test agencies/examining authorities, government, and the institutes, organisations and associations with a professional interest in one or more aspects of technology such as design, engineering or economics. In any democratic system, therefore, the schooling of technology is ultimately a matter of negotiation at a variety of levels, even when, as currently in England and Wales, central government seeks to define a statutory technology curriculum in terms of attainment targets, programmes of study and assessment instruments.

This paper is based upon a study of the techology education provided in three high schools in the north of England. It was recognised at the outset that the technology education offered in these three schools was strongly influenced by the history of, and the tensions between, those curriculum components (e.g. home economics, handicraft, craft and design, business studies) from which the emergent national curriculum component ' technology' was being constructed. The curriculum history of technical and technological subjects in the secondary school curriculum in England and Wales is particularly complex (McCulloch, Jenkins and Layton 1985, Penfold 1988, Jenkins 1993) and, at the time of this study, the schools were confronted by a choice in the technology course made available by the examining authorities for national certification in the General Certificate of Education (GCSE) examination at 16-plus. This choice was marked by a bewildering array of course titles, and by fractures in the meaning to be given to a term such as design, the meaning of which has, at times, been extended to cover the entire technical or practical curriculum (Hicks 1975). Between them, the three schools in this study offered two courses. Formally titled *Craft, Design and Technology* and *Creative Arts: Design Centred Studies* these courses seemed initially to point in quite different directions. In practice, the aims and assessment objectives of the two courses covered similar topics and were expressed in similar language. More significantly, all three schools, irrespective of the title of the course followed by their year 10 students, claimed to be offering these students a technological education.

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In the early 1990s, such an education promised to differ from earlier ,more vocationally oriented courses by offering students the opportunity to design and make artefacts in response to some perceived need or opportunity derived from 'real' , rather than contrived, contexts and situations. Essentially, therefore, technology education was seen as having to do with 'problem-solving' and with the development of problem-solving capabilities. This, in turn, seemed to imply new teaching strategies and environments and an emphasis upon acting and doing, rather than upon the acquisition of knowledge commonly associated with schooling. Moreover, since technology is essentially concerned with the expression and realisation of human interests, technology education has a strong conative dimension. The expectations of the 'new subject', therefore, were high. However, this paper does not seek to estimate the extent to which these expectations were realised in the three schools studied. Its principal purpose is to expose the issues that arise when these schools attempted to create an 'alternative learning environment' by providing their students with an education which rested upon 'technological capability' as a distinct mode of cognitive experience and activity. These issues, it is suggested, are of fundamental importance to attempts to construct design and technology courses which can legitimately claim to offer a liberal education, rather than a vocational training.

The names of all the schools and the students in this study, carried out during 1990-91, have been changed to protect confidentiality. The research was carried out shortly after the passage of the 1988 Education Act but before the relevant parts of the statutory Order defining the technology curriculum came into effect. The schools' technology curricula, therefore, were in something of a state of transition, the teachers seeking to anticipate, as far as possible, the new obligations likely to be placed upon them. This uncertainty had the advantage of ensuring a lively discussion among the teachers about the nature of technology education and about the kinds of curricula and pedagogical strategies necessary to foster a 'technological capability'. A further, subsequent and not entirely anticipated advantage of the timing of the research was that the questions addressed were not specific to a particular version of the technology component of the national curriculum, a point of some significance as later, amended versions of this component came to be published.

The data for this study were collected by a researcher with substantial previous experience as a school technology teacher. He spent time every week in each of three schools over an entire school year, observing (and where, appropriate, recording) technology lessons and interviewing the relevant teaching staff and some of the students whose classes he visited. All the students were in year 10 (aged 15 years) of their secondary schooling and they were, by common consent of their teachers, not among the more able they taught during a school week. Transcribed accounts of these lessons and interviews, students' notebooks and other materials, together with school and departmental documentation constitute the empirical data of the study. The principal intention of the study was to describe and characterise the curricular, pedagogical, institutional and other dimensions of school technology education in the three schools and to examine the ways in which they attempted to develop and assess students' 'technological capability'. In this paper, attention is confined to students' project work in technology, typically an individual undertaking

over several weeks or even months, and commonly regarded as central to the notion of technology education as a new component of the high school curriculum. A fuller account of the study is available in Donnelly and Jenkins, 1992.

Technology education in the three schools

In Fennel High School, the teacher had chosen the *Creative Arts* course for his students because he believed that it offered him the flexibility of approach he deemed necessary for his work. A valued element of this flexibility was the absence of a formal written examination in favour of 100% school based assessment, governed by the published assessment objectives conforming to the criteria required for public certification as a GCSE examination. In January 1990, students were required to develop design briefs relevant to the theme ' Environments' specified by the teacher who, in an introductory session, outlined to his class what might be encompassed by this title. He indicated contexts such as offices, the home, public spaces and buildings and transport systems which the students could use to identify topics and ideas for the technological projects which would occupy their lesson time for the next fourteen weeks. He was careful not to present students with ready made problems or projects, emphasising instead that the responsibility for identifying a problem, generating a design brief and working towards a solution lay with each student individually. He also emphasised that students were in control of their own work schedules, pointing out that the work would almost certainly involve them working on their projects not just during lessons at school but also in their own time at home. Students were told of the way in which the work was to be undertaken and presented in order to meet the requirements of the public examining authority, and each student was given a set of instructions to help take his or her ideas forward. Typical initial instructions were 'Describe a problem and write down what you will do to solve it' and 'Draw and describe some ideas of answers to your problem'.

Among the students, James proposed to re-design his bedroom, Andrew began to think about designing and making a mural for the school's computer room, Janice wanted to brighten up the outside of her sister's hairdressing salon in the town, and Charlotte, whose family ran boarding kennels for dogs, chose to design a kennel block. These examples serve to illustrate the range of the work upon which the students chose to embark.

Subsequent lessons were inevitably marked by a diversity of activity as the students worked on their tasks. For example, Charlotte sought information about the suppliers of materials needed for her kennel block and Tessa, originally drawn to tidying the jewellery in her own bedroom, designed a questionnaire for her peers to find out what sorts of jewellery they needed to store. The teacher's role here was to offer advice, encouragement and, where necessary, specific help of a procedural or technical kind e.g. about how to make a mould and vacuum-form a product. James, committed initially to re-designing his bedroom, was given a list of questions to think about, relating to cost, storage space, size and type of bed. However, it was some weeks before James was finally able to bring his technological problem into focus. He had found himself unsure whether he was trying to re-design an 'ideal' bedroom for a boy

of his age that could accommodate hi-fi equipment, a personal computer etc. as well as the usual bedroom furniture, or to re-design his own bedroom, within the existing constraints, to meet his own particular needs. As the work on the students' projects continued, design ideas were expressed and refined as sketches and free-hand drawings. Ideas for shapes and materials were tested against several criteria, including cost, availability, ease of working and the overall need to bring the project to some kind of conclusion within the time available. This 'conclusion' was commonly an artefact coupled with its design history and evaluation, presented and assessed in the manner prescribed required by the public examination. Students were required to assess their own work against known criteria and to discuss their assessments with the teacher who went to some lengths to explain when his own judgement was used to overrule that of his students.

At both Borage and Coriander Schools the students followed a *Craft, Design and Technology* course, taught via modules of work entitled structures, pneumatics, mechanisms, microprocessor control and electronics, together with a minor and a major project. Three possible design briefs, concerned with recycling household waste, reducing pollution, and the production of a toy or leisure activity for a handicapped adult, were specified, by the public examining authority, for the minor project.

During the first months of the present study, students at Borage School were taught the 'knowledge' component of their technology course. A module of work on *mechanisms* began with a session devoted to the general nature of machines and moved on to the classes of lever and everyday examples of these. Much of the work would not have been out of place in some physics courses. This was followed by a more practically oriented session dealing with pulley ratios and the construction of devices to convert between, and change the direction of, motions. Some weeks later, the ideas presented during the modular parts of the course were integrated into the task of designing temporary housing for victims of natural disasters. The purpose here was to help students understand the requirements of a design brief and to reinforce the importance of following a 'design cycle', elaborated as 'Brief, Investigation, Ideas, Evaluating, Developing, Planning/Realisation, Testing, and Evaluation'. Work on the design of the temporary housing led to the first of the minor projects set by the examining authority, with the choice of the project left largely to the individual students.

Alan chose to design and make an electronic device to warn when doors were left open or failed to shut properly. His first ideas were based upon using a laser as a sensor but, at the suggestion of his teacher, he subsequently shifted his attention to the use of infra-red radiation. Jenny, after considerable background research, designed and constructed a model of a windmill to be used for power generation but encountered much difficulty with the design of the sails and the mechanism for transmitting power to the generator. Becky found herself studying electromagnetism as the basis of her strategy for separating steel cans from other forms of household waste and Robert discovered that he needed to learn much of the operation of a garden compost heap before he could think seriously about designing an electrically powered shredder of household waste for use in this context. In general, the teacher did not intervene unless students' suggestions were unrealistic, in the sense of being beyond either the material resources available or the relevant manipulative skills of the students. Students

choices of projects, however, were always discussed and the teacher was careful to monitor their work. His approach to individuals varied from general advice to direct involvement by suggesting alternative design or construction strategies.

At Coriander School, the requirements of the examining authority were interpreted somewhat differently. Teachers at the school had developed a supported self-study unit of work on bridge building and all students became involved in studying the detailed textual and other material and constructing a simulated bridge to meet specified criteria. There was much co-operative group work here, allied with considerable competition among the groups. This competition was enhanced by requiring all designs to be carefully costed, using notional prices for the materials to be deployed. The two quantitative elements of component costing and load-bearing capacity were handled using a computer programme and, at the end of this part of the technology course, the bridges were tested to destruction. The study of bridges was followed by work on electronics in which students were required to design a system to prevent the theft of food from a cupboard in a student house. When these various collective activities had been completed, students began on their individual minor projects. Here, as at Borage School, students were drawn to a wider variety of tasks. Wayne wished to design a toy maze with a buzzer so that it could be used by a blind person. Anne sought to design a machine which would compress damp newspaper into 'plugs' for use as fuel. Peter learnt about time delay circuits and micro switches in his attempt to design energy loss monitors for use in a domestic context. In all cases, both the students and their teacher were aware of the importance for assessment purposes of evidence that the students had engaged with all the various elements of the 'design cycle'. Both discourse and practice were influenced by the need to generate this evidence. Projects were concluded ,not by some process of natural closure, by the strict timetable allowed for the completion of the task. The result, inevitably for some students, was work which fell below that which they felt they could have achieved, given more time. For the teacher, working to a pre-set time schedule was part of the project brief and an important aspect of the students' learning process.

Knowledge in Action?

Conventionally, a secondary school curriculum is school-centred and subject-based, with the units of teaching, the lessons, forming a coherent and largely self-contained sequence, based around a well-defined body of knowledge or, in the case of the arts, legitimate affective responses. The technology education offered in each of the three schools, particularly at Fennel High School, presented some contrast with this convention. The work took place over a relatively extended period before any material was presented for assessment by the teacher. For some of the time, students were working away from, and independently of, their teacher, sometimes elsewhere in the school and occasionally in a location well away from the school site. The activity reflected a commitment on the part of the teachers to 'knowing how', rather than 'knowing that', and the work emphasised the practical rather than the academic by highlighting the students' individual responses to needs and opportunities at the expense of a cognitively authoritative framework. The projects undertaken were very diverse and the associated competencies and knowledge bases were correspondingly wide. The approach might be called eclectic, and the field itself exogenous. One of the

teachers in the study advised his students that once in the technology room, they were in 'the future', a reference to his belief that technology was about designing and making things which did not yet exist.

The three schools, therefore, offered clear evidence of a curricular domain which aspired to transcend the usual curricular categories of schooling and to constitute a learning environment in which students had a substantial degree of control over their own learning agenda and worked in a way which was simultaneously practical and intellectually challenging.. In addition, technology as a curriculum component did not follow the normal trajectory for school subjects. It has been claimed that this trajectory involves an initial emphasis on utility, followed by a stress on academic values and a codified body of knowledge (Layton 1991). In contrast to this claim, the technology courses at the three schools did not aspire to achieve enhanced status by drawing upon high-level discursive knowledge, notably scientific knowledge. Indeed, all the technology teachers interviewed as part of the present study were clear that scientific knowledge constituted no more than a potential resource, among many others, for the resolution of technological problems.

In Borage and Coriander schools, the various modular courses concerned with electronics, mechanisms etc., constituted an attempt to 'front-end load' the knowledge required to undertake successfully the subsequent technology projects. In contrast, the teacher at Fennel High School attempted to provide students with knowledge on what was essentially a need to know basis. The essential distinction, however, lay less in front-end loading and knowledge on demand, than in the extent to which the knowledge required for a particular project was, or even could be, made available in the form in which it was needed for the work in hand. Writing of the relationship between scientific knowledge and technological activity, Layton has drawn attention to the re-packaging, reconstruction and adjustment of knowledge that often has to take place before it can articulate effectively with the design parameters of a specific technological task (Layton 1993). Although this reworking of knowledge was necessarily implicit in much of the work of the technology teachers at all three schools, their perception of the relationship between knowledge and technological activity was expressed very differently, largely in terms of a distinction between 'theory' and 'practice'. Theory is not used here merely to indicate a body of declarative knowledge as in the 'content' component of a technology course. It refers also to a particular pedagogy, identified with the teaching of decontextualised, atomised material, a reference which is commonplace in discourse about technological activity. 'Theory' in this context, therefore, means removal from the concrete, real or whole situation, and it carries pejorative overtones (It's alright in theory'). For the teachers in the three schools, theory was fully legitimate in pedagogical terms only when integrated into a whole design situation. Without this integration, it was simply a case of 'theory for theory's sake'. The teachers claimed, forcefully and with some disparagement, that it 'made sense' to talk of technological knowledge only in the context of a technological activity of which that knowledge was an integral aspect and thus lacking, at least for the most part, any independent status and generality.

Despite this rhetoric, the teaching strategies adopted by the teachers at Borage and Coriander schools tended to present knowledge largely in a de-contextualised manner, so that it occupied separate lesson space or even separate lessons. A number of distinct

reasons were, or might have been, offered for this. Both schools claimed that the pressures of the end-of-module tests required the separate teaching of the technological 'content'. In addition, one school offered a second argument:- teaching most of this content ahead of students' project work gave the students access to a wider knowledge base which was useful in identifying, shaping and undertaking their project tasks. Both of these justifications sit uneasily with the view that 'theory' is best taught through project work and the latter entails assumptions which are not supported by the study. Even when a body of knowledge (e.g. basic micro-electronics) was in principle relevant to some technological activity (e.g. the design and construction of a micro-electronically controlled device), students did not make spontaneous use of the knowledge to which it was supposed they had access. In all cases, students needed to be directed towards it. Students found it difficult to know whether or when a particular knowledge was relevant to the task in hand. Moreover, even the relevance was correctly identified, the questions remains of how the discursive knowledge is used, or to use the more common term, applied. The research study suggested that the notion of application, understood as some kind of deductive reasoning from general principles, is of doubtful value in discussing the interaction of knowledge and action in the context of school technology education. A better phrase might be *selective appropriation*, since a simple transference of knowledge resources with minimal manipulation ,such as the use of a circuit with a specific function, appeared to be the only significant mode in which students drew upon the knowledge base to which they had been introduced. It has been argued that practitioners in particular technical areas may have tacit or explicit intermediate categories to make use of any discursive knowledges (Layton 1993). If this is the case, the studies outlined above suggest that the process receives little attention in school technology. Moreover, the central creative process involved in solving a technological problem is unlikely to be reducible to the notion of 'using' existing knowledge. It is more likely to be a novel synthesis of ideas, images and systems. From several perspectives, therefore, it can be argued that each student engaged in a technological project is required to generate a novel integration of knowledge and practice within the context of the project itself. The difficulty of this task does not need to be emphasised. Overall, the effort and time devoted to communicating discursive knowledge and the complexity of that knowledge contrasts strongly with the limited effort given to identifying the legitimate forms of such knowledge and the under-conceptualisation of the means by which it is put to use.

The notion of technology as an 'applied' activity was much less evident in the teacher's account of the technology curriculum at Fennel High School. Given the nature of the course, the notion of application was played down in favour of 'creativity', 'innovation', 'intuitive and imaginative abilities' and 'aesthetic awareness'. In general, the language used by the teacher discussing his technology course came close to that associated with the arts and humanities. Such usage indicates that design as a curricular category is under tension from aesthetic and technological formulations (Donnelly 1992).

At both Borage and Coriander schools, further explanations were offered of the presentation of 'relevant knowledge' in a largely de-contextualised manner.
First, it was suggested that the organisational and resource demands of an 'ideal' pedagogy, in which knowledge is integral to both the formulation and the resolution of a technological problem, presented an insuperable barrier to its adoption. Experience at

Fennel High School suggested that while this was not necessarily the case, the demands upon the technological skill and knowledge of the teacher were, theoretically, unlimited and the requirements for class management were often severe. Finally, Coriander School implied that the staffing situation (i.e. the background of teachers in home economics, business studies, art or science) determined, or even over-determined the pedagogy which was adopted to 'teach technology'.

The emphasis given by the teachers at Borage and Coriander schools to teaching a body of 'relevant knowledge' while acknowledging that this is at odds with their expressed views of technology as a holistic undertaking reflecting the notion of 'knowledge in action' is not easy to explain. It may be related to the attempt in England and Wales in the 1970s and early 1980s to raise the status of craft and other curriculum precursors of school technology. A feature of this attempt was the emphasis given to a body of rigorous theoretical knowledge as the core of the emerging subject. The science curriculum is the commonest location of what is identified as theoretical knowledge in a school and this may have provided at least some technology teachers with a model for their new pedagogy. However, 'theory' in school science lessons is not merely a cognitive category. In the everyday discourse of school science (in the staffroom, teaching laboratory or preparation room), 'theory' represents a form of classroom organisation as much as a body of established knowledge. Students are thus engaged in 'theory' or 'practical' lessons, the latter marked by working with apparatus and characterised by greater freedom of student movement and interaction. It is possible that technology teachers, seeking to escape the narrow craft tradition, borrowed not merely the language but also the organisational strategies and practices of school science education. When technology teachers attempted this shift, partly by arguing the importance of discursive knowledge of a quasi-scientific kind to their work, they perhaps adopted more than they intended.

The emphasis on knowledge in the context of usage which was given strong rhetorical support by the teachers in this study is arguably a distinctive feature of a technological education. It stands in marked contrast to the conventional pedagogy of most school subjects which stress the universality and de-contextualised nature of scientific understanding and offer, as Barbara Rogoff has recognised, a radical challenge to the 'Euro-american institution of schooling which promotes an individually centered analytical approach to tools of thought and stresses reasoning and learning with information considered on its own ground, extracted from practical use (Rogoff 1990: 191). In addition, the integration of knowledge with action suggests that the development of students' understanding is less a matter of mastery of principles or concepts that of 'cognitive apprenticeship', of induction into the processes whereby novices become part of communities of practice, each of which is engaged in its own replication and reproduction (Lave and Wenger 1990).

The fact that this apprenticeship was not much in evidence at any of the schools studied should not occasion surprise. The range of practical activities undertaken was very wide and the context is that of the school not of the world in which 'real' technological activity takes place. The schooling of such activity is shaped by two kinds of processes that might be called *curricularisation* and *intellectualisation.*

The former refers to the direct imperatives of schooling on the activities in which students engage. Assessment and testing are the most obvious and powerful of the forces involved. Other factors include the timetable which determines when technological activities can be undertaken and when it must be terminated for assessment purposes. In the context of an 'applications' model of technology education, it also constrains the knowledge which can be applied for technological ends.

A more subtle effect might be accommodated under the heading of *curricularisation*. This is the way in which school technology courses adopt a 'cottage industry' approach, rather than one based on a division of labour. The rhetoric and the strategies of real-life technological problem-solving are not carried over into the environment of the school (Medway 1989) and a set of schooled and, therefore, contrived 'technology problems suitable for educational use' comes to be deployed.

The second process, *intellectualisation*, refers to a privileging of the cognitive dimension, of analysing, investigating and constructing images in words or diagrams and of outcomes which are essentially pedagogic or assessment artefacts. Correspondingly, it undervalues the 'thinking hand', the notion of knowledge in the context of use, which allows for tacit responses based upon experience and familiarity with materials and techniques. It marginalises the kind of technological activity which are most immediately technical and cannot be dealt with by some process of design and planning. (Arguably, the thrust towards intellectualisation is also implicit in the very term technology, rather than technique, and its sharpest manifestation is in the attack on handicraft skills).

Between them, the schools in this study reflected what might be called 'design' and 'application' approaches to the construction of a school technology curriculum. Whatever approach is employed, however, is likely to be susceptible to the thrust towards intellectual codification and away from the practical. This threat embodies a legitimate if paradoxical question. What elements of technological activity can be systematically identified in schools and by what means can they be promoted? Whatever the answer to this question, a focused and structured framework is likely to be needed. Likewise, the balance between the quality of, and pride in, technological artefacts themselves and a recognition of the cognitive dimension of technical practice will need to be clearly visible. These features were not much in evidence in the schools studied. Indeed, how to achieve them is a major strategic and historical question, the answer to which has been given a new urgency by the attempts, in many countries of the world, to develop a liberal technological education at school level.

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